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ABSTRACT TITLE: Novel Horn Designs for Ultrasonic/Sonic Cleaning Welding, Soldering, Cutting and Drilling

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ABSTRACT TEXT

A variety of Industrial applications exist where power ultrasonic elements such as the ultrasonic horn are used. These included the Automotive, Instruments, Foods, Medical, Textiles and Material Joining and Fabrication Industries. In many of these devices the ultrasonic horn is the key component. The standard transducer used in these devices consists of three main parts, the backing, the piezoelectric elements and the horn. A horn is a solid of length L in contact with the piezoelectric material, which in general tapers to a small diameter at the tip of the horn. The tapering of the area of the horn is used to amplify the limited displacement of the piezoelectric material. Standard horn designs have changed very little since their inception. There are four general designations of standard horns. They are; constant, linear, exponential and stepped, which refer to the degree to which the area changes from the base to the tip. A magnification in the strain occurs in the horn that in general is a function of the ratio of diameters. In addition the device is generally driven at resonance to further amplify the strain. The resonance amplification is in general determined by the mechanical Q (attenuation) of the horn material and radiation damping. The horn length primarily determines the resonance frequency. For a 22 kHz resonance frequency a stepped horn of titanium has a length of approximately 8 cm. Although these standard horns are found in many current industrial designs they suffer from some key limitations. In many applications it would be useful to reduce the resonance frequency however this would require device lengths of the order of fractions of meters which is impractical. In addition, manufacturing a horn requires the turning down of the stock material (eg. Titanium) from the larger outer diameter to the horn tip diameter, which is both time consuming and wasteful. In addition the displacement of the horn tip is the result of the longitudinal strain in the material. In this paper we will present a variety of novel horn designs, which overcome some of the limitations discussed above. One particular design that has been found to overcome these limitations is the folded horn. In this design the horn elements are folded which reduce the overall length of the resonator. In addition the tip displacement can be further adjusted by phasing the bending displacements and the extensional displacements. The experimental results for a variety of these novel horn designs will be presented and compared to the results predicted by theory.

KEYWORDS: Ultrasonic/sonic driller/corer (USDC), inversed horn, ultrasonic drilling, planetary exploration, piezoelectric devices, Active Materials.

BRIEF BIOGRAPHY: Dr. Stewart Sherrit joined the JPL's NDE& Advanced Actuators (NDEAA) in Sept. 1998. He is working on the development of finite element model and experimental capability for ultrasonic drilling of rocks at planetary conditions. Dr. Sherrit received his B.Sc. in engineering physics (mechanical option), M.Sc. (Solid State Physics-Thermoelectric Conversion) and PhD (Physics Characterization of losses, dispersion and field dependence of piezoelectric and electrostrictive material properties) from Queen's University, Kingston. Prior to joining JPL he worked in the Applied Solid State Research Group at Queen's as a research engineer involved in thin film piezoelectric and ferroelectric devices. In 1988 he moved to the Physics Department at the Royal Military College of Canada where he was involved in developing new techniques to characterize electromechanical materials. He has authored over 30 papers in the field of electromechanical materials and has been invited speaker at international meetings. His most recent interests have been in modeling of the field and stress dependence in ferroelectric and electrostrictive materials including hysteresis.